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Mole Attack	Personal Finance
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commodore COMPUTER

WELCOME ABOARD

You are at the controls of a spaceship travelling through our Solar System. A camera attached to your ship lets you observe the orbits of the planets and also view them at close range. Mathematical knowledge about the Solar System has been programmed into your VIC, which creates a scaled down version of the real Solar System. The "computer simulation" is so much like actually being in space that you can enjoy a solar adventure in your own home or classroom. Your ship is equipped with both a short range and long range viewing screen as well as an on-board computer system which displays facts about the Solar System and does many interesting calculations for you. Let's climb aboard ship (plug in your cartridge) and take a short guided tour to become familiar with the controls.

The VISIBLE SOLAR SYSTEM is organized into three program sections. They are the ORBITS screen, the PLANETS screen and the PLANETARY COMPUTER screen. Each is a self-contained unit. You can learn about them separately, or flip from one to another as you want. This manual contains thorough instructions on the operation of the three screens as well as facts, concepts and ideas that can broaden your ability to use the VISIBLE SOLAR SYSTEM.

Press F1 to begin. You are 400 million miles above the Sun looking straight down on the orbits of the four nearest planets—Mercury, Venus, Earth and Mars. Notice that the planets travel in nearly circular orbits. The Sun, not shown because of its blinding brilliance, is at the center of the orbits. Orbits happen on what is called the Solar Plane. From your ship's position, 400 million miles above the Solar Plane, the orbits look small. Mercury, in the smallest orbit, is 36 million miles from the Sun. The Earth is 93 million miles from the Sun, and Jupiter is 484 million miles, well beyond the border of your screen.

If you want to learn to fly your ship now, continue with this section of the manual. If you want to flip ahead to another screen, then go to the topic USING SCREEN PROMPTS.

ORBITS SCREEN – INSTRUMENTATION

Look at the upper right of your TV where you see the names of several planets and changing numbers. Those are the planets which are closest to the ship. A WHITE number means that the planet is in front of the ship and BLUE means that the planet is in back of the ship. Since the ship's camera is looking straight down onto the Solar Plane, the point directly under the ship

is also at the center of your viewing screen. (The center of the viewing screen is the center of the field of vision of the ship's camera.)

Look for the name VENUS and notice that the instruments read 080. Multiply 080 by 5,000,000 to find out the distance in miles from your ship to VENUS. 80 x 5,000,000 = 400,000,000 miles from the ship to VENUS. Watch the 080 change color as VENUS moves around the Sun.*

When a planet moves once completely around its orbit, we say that it has completed one revolution around the Sun. The amount of time it takes to complete one revolution is called a year. The closer a planet is to the Sun, the faster it moves and the smaller is its orbit. Mercury, the planet nearest to the Sun has a much shorter year than Earth, the third planet from the Sun.

On your view screen you can see that the Earth is completing one revolution in about 56 seconds; Mercury in about 14 seconds. In other words, 56 seconds in the VIC VISIBLE SOLAR SYSTEM model equals one year on Earth. Mercury revolves around the Sun slightly more than four times during each year on Earth.

NAVIGATING YOUR SHIP

Now let's fly the starship. The X, Y, and Z numbers on the upper left section of the screen tell you the ship's position in space. X is how far you are from the sun moving side to side (CRSR). Y is how far you are from the Sun moving up and down the screen (CRSR). Z is your altitude (height) above the Solar Plane. Using the cursor control keys on the bottom right of the keyboard, you can move in the X and Y directions shown by the arrows on the keys. Pressing the Z key moves you away from the Solar Plane. Pressing the Z key while holding down the SHIFT key moves you toward the Solar Plane.

BLUE and WHITE instrument readings are used to tell you which side of the Sun you are on. BLUE is when the planet is "behind" the ship, WHITE is when the planet is "in front" of the ship. (See Diagram 1).

The diagrams below are study aids. They will help you understand more about what you see on the screen. Try the maneuvers and watch what happens on the screen.

MANEUVER 1: Use the cursor controls keys to fly your ship. Fly to the positions shown in diagram 1.

* See Appendix C

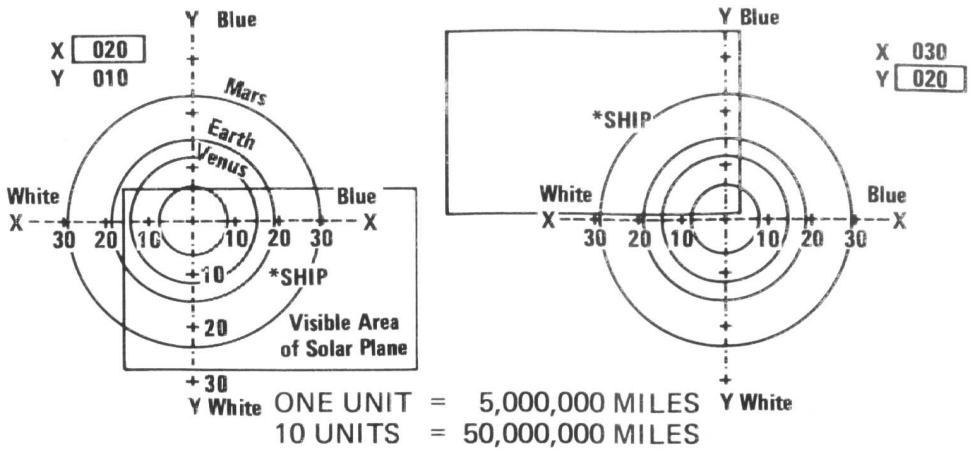


Diagram 1. Shaded Blocks depict the Blue Background on the Screen (meaning the Planet is behind the Starship). The planets move in the orbits as shown. Your ship is 80 units (400,000,000 miles) above the paper (Z direction). In both examples above, your ship is located where the * is. The area on the Solar Plane that is within the field of vision of your camera is outlined. That is what you see on your screen.

MANEUVER 2: Using the cursor control keys, fly to position.

Use X and SHIFT X to make	X = 000 (white)
Use Y and SHIFT Y to make	Y = 090 (white)
Use Z and SHIFT Z to make	Z = 090 (white)

Your camera is still looking straight down from the ship.

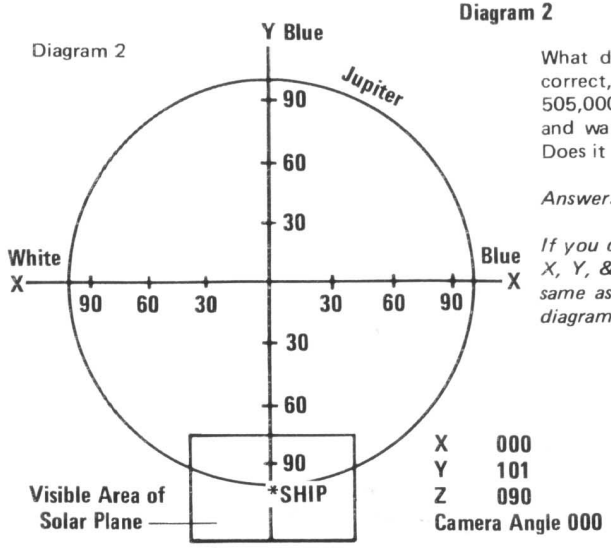
Camera Angle = 000 (white)

Your ship's camera is still looking straight down from the ship. As you move from Y = 000 to Y = 090 (white), your ship is moving away from the Sun, passing over the orbits of Mercury, then Venus, then Earth, then Mars. When you reach Y = 090, you will see the much larger orbit of Jupiter on the bottom of your view screen.

QUESTION: HAVE YOU REACHED THE ORBIT OF JUPITER?

ANSWER: Not quite. If the ship was directly over the orbit of Jupiter, you would see the orbit passing through the center of the screen (directly under the ship). If you want to see how far Jupiter is from the Sun, then move your ship to a position directly over its orbit (with X = 000) and look at the Y distance. To move the ship 1 unit at a time (1 unit = 5,000,000 miles), press H. To switch back to 10 units, press H again. Notice the X, Y, & Z, co-ordinates in diagram 2.

Diagram 2



What did you measure? 484,000,000 miles is correct, but you will probably measure about 505,000,000 which is within 5%. Take a minute and wait for Jupiter to pass across the screen. Does it pass behind the ship?

Answer: YES

If you did not get the correct answer check the X, Y, & Z numbers on the screen. Are they the same as the numbers to the lower right of the diagram 2?

LET'S GET THREE DIMENSIONAL

MANEUVER 3: Using SHIFT Y fly to Y = 90
Using SHIFT Z fly to Z = 050

Don't forget that the "H" key lets you move in either 1 unit at a time or 10 units at a time, depending upon how many times you press the key.

You should now be at STARSHIP COORDINATES

X = 000 (white)
Y = 090 (white)
Z = 050 (white)

If not, corect your position.

There is nothing in the field of vision of your camera, so let's rotate it forward to look at the orbits of the four inner planets from our position near the orbit of Jupiter.

By pressing the < key you can rotate the camera forward all the way to 090 degrees (WHITE) which points straight ahead of the ship. The > key can rotate the camera back as far as 035 degrees (BLUE) which points down, but somewhat behind the ship.

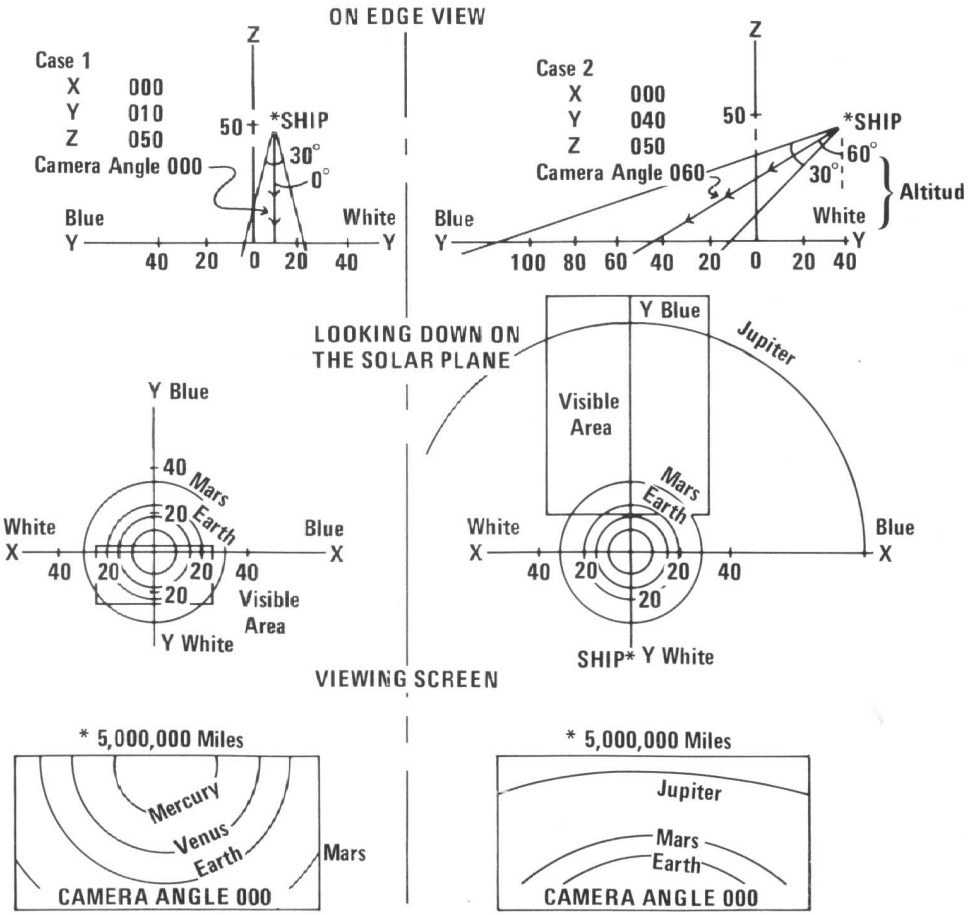
Rotating the camera is like moving your head. A camera angle of 000 is like looking down at your feet. A camera angle of 090 is like looking straight ahead. A camera angle of 045 is half-way between. (See diagram 3).

RIGHT NOW PRESS < 10 times and watch what happens as the camera scans forward. When you reach camera angle 050 you will see the orbits of Mercury, Venus, Earth and Mars as they appear from your ship's new position. Now press < 3 more times and a three-dimensional view of the Solar System will be in view (camera angle 65). Near the top of the viewing screen is the orbit of Jupiter. Notice how much larger it is than the orbits of the four inner planets.

Diagram 3.

In case 1, the camera is looking straight down from the ship, just like it did before. You changed the camera angle. Instead of looking down onto the Solar Plane, the top drawings show the Solar Plane seen on edge. (If you hold a piece of paper on edge in front of your eyes, you see only a line.) This lets you draw the Z direction up from the Solar Plane to show the ship's altitude. The middle drawing looks down on the Solar Plane. The bottom drawing shows how the visible area of the Solar Plane in the field of vision of the camera looks.

In case 2, you have rotated the camera to look down, but also 60 degrees ahead of the ship. You see more of the Solar Plane, and you see it in a three-dimensional perspective.



SOME FANCY FLYING

MANEUVER 4: Move your ship up, down and sideways using the CRSR,→ CRSR↑& Z keys. Also use the < and > keys to keep the inner planet's orbits within the viewing area. Use the "H" key to adjust your speed. Switch back and forth from hi-speed to lo-speed until you reach the starship coordinates below.

VOYAGE 1: Fly to starship coordinates

X = 013 BLUE
Y = 026 WHITE
Z = 018 WHITE
Camera Angle = 000

You are now over the orbit of Mars. Fly your ship over the Solar System, moving forward (by holding SHIFT and the adjacent cursor key) until you reach the orbit of Mars on the other side of the Sun (about Y = 024 BLUE). Then press H to go into hyperdrive (10 units per movement) and return to where you started Voyage 1. From this position scan forward with your camera to angle 085 (just about straight ahead) and back again. Spend some time making observations.

You have just passed your basic training as starship commander. We have a few more tips for you before you take off on your own.

You may use the X and Y keys and SHIFT X and SHIFT Y in place of the cursor keys if you wish. If you use the cursor keys, you can move continuously just by holding down the key. This gives you a nice feeling of continuous motion. You can get the same effect using any of the other keys by pressing them repeatedly. The VIC will store up to 12 key presses and execute them automatically.

The edge of the model Solar System is X = 128 and Y = 128. If you go off the edge, you will re-enter at the other side.

Your maximum Z is 255 and minimum Z is 11.

USING SCREEN PROMPTS

On the bottom of the ORBITS screen you see the words COMPUTER and PLANET with the first letter of the word in reverse. When the first letter of a word is in reverse or in a contrasting color to the rest of the word this is to prompt you to press that key in order to access a different part of the

VISIBLE SOLAR SYSTEM.

PLANETS SCREEN – VIEWING THE PLANETS

The VISIBLE SOLAR SYSTEM contains detailed models of the planets Earth, Mars, Jupiter and Saturn. Mercury, Venus, Uranus, Neptune, and Pluto are outside the viewing range of your starship. Mars, Jupiter and Saturn are visible from the Earth with a small telescope, and appear like bright stars to the naked eye. Venus is also visible from Earth but it is covered with a dense cloud layer without visual detail. Closer to the Sun is Mercury a tiny, rocky, barren and hot planet. Beyond Saturn are the large and similarly icy planets Uranus and Neptune, and tiny Pluto.

From the ORBITS screen, press P to see the planets. Across the top of the screen you can see a diagram of the Sun and the 6 tiny planets. The blue star indicates which planet you are looking at. Some basic information about the planets' size and motion is given.

ORBIT is the average distance from the Sun in miles.

RADIUS is the distance from the surface of the planet to its center in miles. Since observation of the planets from Jupiter outward is difficult, their radii are measured from the top of their cloud layers.

YEAR is the number of EARTH days it takes for the planet to revolve around the Sun.

DAY is the number of EARTH hours it takes for the planet to rotate once.

MOONS is the number of moons the planet has revolving around it.

Notice the prompts on the bottom of the screen. To change planets press P. To access the computer press C. To Return to the Orbits Screen press O.

JOURNEY THROUGH OUR SOLAR SYSTEM

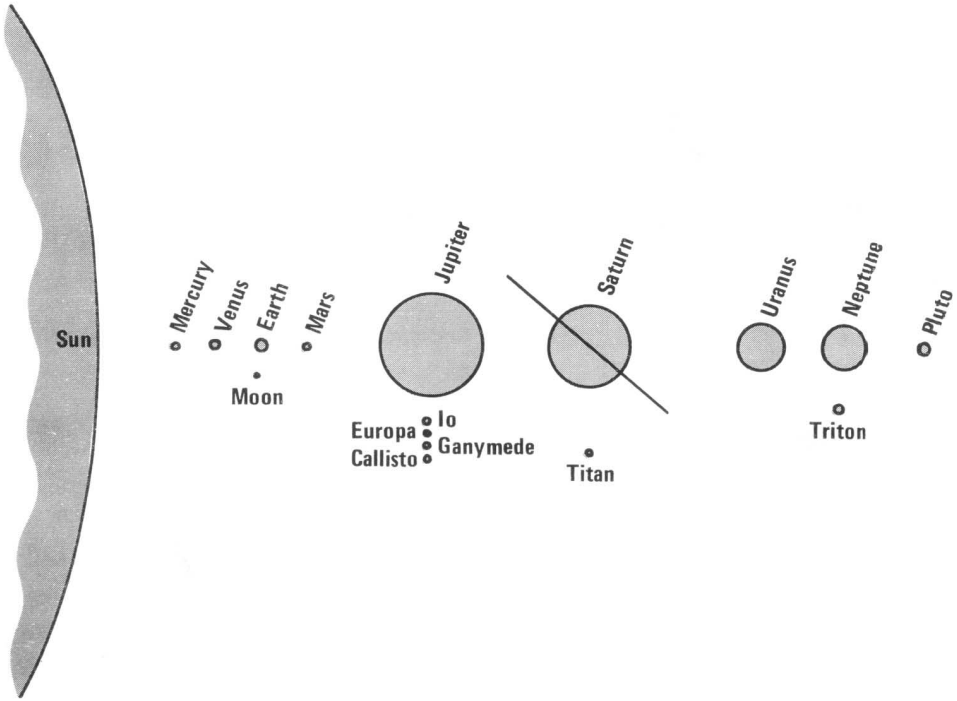
MERCURY

Mercury is the smallest of the nine planets and is also the closest planet to the Sun. Mercury appears to not have any real atmosphere, which is

consistent with its small mass and high surface temperatures. This planet's close proximity to the Sun allows it to have rather hot temperatures despite the lack of atmosphere (which would tend to help the planet retain heat). The temperatures range from 110-700 degrees Kelvin (approximately 721-1783 degrees Fahrenheit). No well-defined features such as craters appear to exist on Mercury. Mercury does not have any satellites or moons, and is made up of primarily dense materials such as iron.

VENUS

Venus is the second planet away from the sun. Completely surrounded by cloud cover, it is one of the brightest objects to be seen on the solar sphere. The surface temperature of Venus appears to be around 1800 degrees Fahrenheit! We know almost nothing about the interior of Venus because of all the clouds and haze in its atmosphere, but scientists believe it to be very similar to that of the earth.



Planetary Sizes. In relation to the Sun, the sizes of the nine planets, Saturn's rings, and the seven largest moons are shown.

EARTH

The outline of the continents are shown. What countries can you identify? Can you identify any of the United States sea-coast states? Most of us have seen photographs of Earth from an orbiting spacecraft. On such photographs, a portion of the Earth's surface is obscured by the clouds of the planet's weather patterns. On your screen, the land masses are outlined in order to be seen clearly. About 2/3 of the Earth is covered with water. Can you name some of the Oceans and Seas?

The temperatures on our friendly planet are moderated by the atmosphere which keeps the heat of the surface from escaping rapidly into space. Conditions on Earth are balanced for life. This is not so on any of the other planets in our Solar System. Venus as an example has such a dense atmosphere that the heat from the Sun which warms it gets trapped. The temperature on the surface of Venus is over 875 degrees F. which is even hotter than Mercury. Though there are a few other places in the Solar System where some kind of life could be possible, none has been found.

Earth's atmosphere consists mostly of a relatively inactive gas, nitrogen. There is about 20% oxygen, which animals breathe, and 2% carbon dioxide, which plants "breathe" during the day. During the day, plants convert the carbon dioxide to oxygen, which is very nice for the animals. The animals, in turn, exhale carbon dioxide, which is nice for the plants.

The Earth has one unusually large moon. Its radius is 1080 miles, 2/3 the size of the planet Mercury.

MARS

Mars is the fourth planet from the Sun. It is smaller than Earth and has little atmosphere to keep it warm. Its year is about twice that of Earth but its day is about the same. What you see on your screen is the pinkish color of the surface and some markings which are the major surface features discovered by our space probes. There are many craters, mountains, and tremendous volcanoes. There is a little water on Mars, mainly as frost at the two poles. The water and winds of the thin atmosphere have eroded the surface and large sand dunes have been photographed by spaceprobes that have landed on the surface of the planet. Mars has two small moons. During the day the surface temperature of the planet can rise above 0 degreees F.

Asteroids, Comets and Meteors

There are other objects in our Solar System besides the planets.

Asteroids are smaller objects (as tiny as dust to several hundred miles in diameter) which travel around the Sun in an orbit between Mars and Jupiter.

Comets are small objects at great distance from the Sun. Some Comets travel in unusual elongated orbits that approach close to the Sun at one end. When they do, we see a long trail of debris which escapes from the Comet when it gets heated by the Sun.

The debris can get trapped by the gravity of a planet. Most of the Meteors, or "shooting stars" we see on Earth are from this debris burning up in our atmosphere. Sometimes a stray asteroid will be caught by Earth's gravity.

JUPITER

Jupiter is a giant gaseous, cold planet. Very little heat reaches it from the Sun. The picture on your screen shows some of the bands of dense clouds which entirely surround the planet. Jupiter is smaller than a star, but in many (possibly most) solar systems in the universe, a planet like Jupiter will grow to maybe 10 times Jupiter's radius and become a second smaller star orbiting like a planet.

The planets from Jupiter outward are not at all like the four inner planets. The inner planets are small and rocky, while the outer planets are larger and consist mainly of gas with frozen gas surfaces. Jupiter's atmosphere is so deep and dense that it may not even have a clear surface. The pressure deep in the atmosphere changes the clear distinction between gas, liquid and solid material as we know it on Earth. The atmosphere of Jupiter is mostly hydrogen and helium like our Sun. A notable feature in the atmosphere is the giant red spot which is a tremendous atmospheric storm. There is a warm layer in the atmosphere which may reach a temperature of 60 degrees F., though elsewhere temperatures drop to below 200 degrees below zero F.

SATURN

Saturn's surface is probably frozen ammonia and methane gases. Like Jupiter, we see a banded, dense atmosphere. Saturn's distinctive feature is its ring system which was recently studied by the Voyager space probes. The rings are from 1 to 40 miles thick and are mainly small icy particles of frozen gas. The temperature on Saturn drops to 300 degrees below zero F.

URANUS

Uranus is the seventh planet from the Sun. Uranus has five known moons

which range in diameter from about 400 to 1000 kilometers. This is a rather large planet in both volume and mass, but has a rather low density (much like Saturn and Jupiter). Since Jupiter, Saturn, Uranus and Neptune are all similar in their composition and structure (large gaseous spheres), these four planets are given the designation of "Jovian" planets.

NEPTUNE

Neptune is the eighth planet from the Sun. Neptune has two known orbiting moons: Triton and Nereid. Similar to Uranus, gases (such as hydrogen and helium) still play a major role in Neptune's composition. Other gases such as ammonia and methane also appear in Neptune's cold, blue atmosphere. Neptune can be seen only with the aid of a telescope.

PLUTO

Pluto is the ninth and outermost planet from the Sun. The physical characteristics of Pluto are still largely unknown because it is rather difficult to observe. It is generally thought that its dimensions may resemble that of our moon. Since it is so far away from the Sun, it is surely a very cold planet without any real atmosphere.

VIC 20 PLANETARY COMPUTER

Press C to access the ship's PLANETARY COMPUTER. The computer contains files of planetary information. You can access this 'data base' directly and also have the VIC perform some interesting calculations using the data base.

PLANETARY DATA

To get information about a planet, press P from the Planetary Computer screen. Enter the planet number as follows:

1 – Mercury
2 – Venus
3 – Earth
4 – Mars
5 – Jupiter
6 – Saturn
7 – Uranus
8 – Neptune
9 – Pluto

On the top of the screen you see the name of the planet and its distance to the Sun in miles. Notice the two prompts, E to exit and A for Astrocalc which we will discuss in a minute. In the left-most column are the topics and units of measure for the information given in the middle column.

The topics are:

Radius in miles
Length of the planet's year in Earth days
Length of the planet's day in Earth hours
Number of moons

The speed of the planet in its orbit in miles per second.

Escape velocity in miles per second: Loosely speaking, escape velocity is the speed at which a rocket would have to travel to escape from the gravitational pull of the planet. Any object travelling at less than escape velocity must eventually fall back to the planet's surface.

Three temperature readings: These are the typical readings given in astronomy texts for the planets. On the giant planets the measurements are made at the top of the cloud layer. On the smaller planets the measurements are made at the surface. A -*- means that data does not apply to the planet. Surface temperatures on the giant planets can't be measured because the clouds are so deep and dense. The surface temperature of Venus is known because a space probe has actually landed on its surface and measured its temperature. An extra reading has been included for a warm band in Jupiter's atmosphere. Temperature readings are daylight average readings in either positive or negative degrees Fahrenheit.

ASTROCALC

The planets of the Solar System are very different. Astrocalc is an easy way to compare the first six planets with each other. Astrocalc is the right-most column on the screen (refer to diagram 4). By pressing A you can change the planet used for comparison. Here is an example of how to use Astrocalc.

Go to the Blue Planetary Computer screen by pressing E. Press P and select planet #2, Venus. On top of the right-most column you see the name MERCURY. Look in the Astrocalc column and you will see that the radius of Mercury is .3 times the radius of Venus. Now press A. Astrocalc is now comparing Venus with Venus so all comparisons are = 1.0. Press A again. The Earth is now being compared to Venus. In the Astrocalc column you see that Earth's

radius is about the same as Venus. Earth's year is 1.3 times as long as the Venus year. Earth's day can't be compared to Venus' because the day on Venus is so large (3832 hours). The moons can't be compared because Venus doesn't have any. The orbital velocity of Earth is .8 times that of Venus; in other words, Earth travels more slowly than Venus does.

There are two additional comparisons (in white) done by Astrocalc. They are comparisons of distance from the Sun and the strength of the planet's gravity. Earth is 1.3 times as far from the Sun as Venus. Earth's gravity is 1.1 times as strong as that of Venus **

The answers you get from Astrocalc are not exact, but are very good for quick comparisons.

Use Astrocalc to compare Venus with the other planets. As you compare the planets in the VISIBLE SOLAR SYSTEM, you will see what a special place the Earth is. Some scientists think that there may be many planets like the Earth in our galaxy of stars. Others think it is unique. The argument depends on the likelihood of solar systems containing second stars in the place of a large planet like Jupiter. If a second star is present, then it is unlikely that a small hospitable planet like the Earth exists in that solar system. Some scientists think that most stars do not have solar systems similar to ours.

YOUR WEIGHT AND AGE ON THE PLANETS

Start on the blue Planetary Computer screen.

To know your weight and age on the other planets, press Y. Hit the M or L keys as shown on the screen to set your weight (within 10 pounds) and age (within 1 year). Remember to press C when the number in the box is correct.

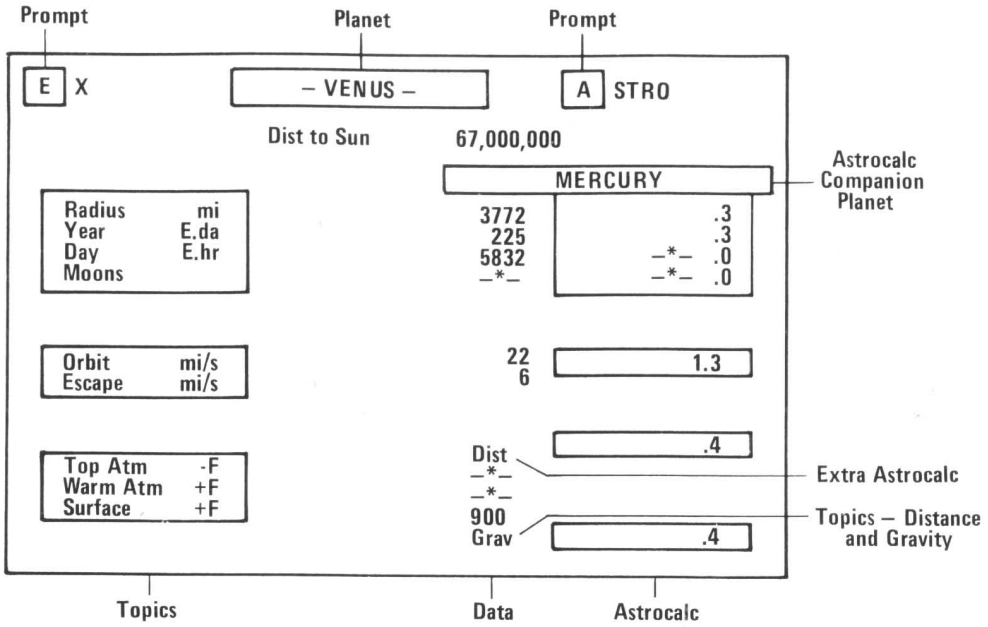
Your weight and age is calculated from the following equations:

$$\text{WEIGHT} = \frac{\text{GRAVITY OF OTHER PLANET} \times \text{YOUR WEIGHT ON EARTH}}{\text{GRAVITY OF EARTH}}$$

$$\text{AGE} = \frac{\text{YEAR OF EARTH} \times \text{YOUR AGE ON EARTH}}{\text{YEAR OF OTHER PLANET}}$$

** See Appendix C

Diagram 4



APPENDIX A

The VISIBLE SOLAR SYSTEM is an excellent model of our Solar System. It contains a remarkable amount of information and calculating ability for a home computer. The Solar System, however, is vast and diversified. As the limits of the model are approached the resolution diminishes and some inconsistencies may be introduced. The following is a list of a number of unusual circumstances which may somewhat disrupt your starship's monitors. Since you are the commander of this starship, you should be aware of these possibilities.

ORBIT SCREEN

1) The relative speed of the planets on the screen is correct. However, when only 1 or 2 orbits are displayed the planets will appear to move faster than when 3 or 4 orbits are displayed. If you are trying to make comparative time measurements, be sure that the orbits of all the planets you are concerned with are displayed on the screen together.

2) Jupiter appears to move three times faster than it actually does in relation to the other planets.

3) As you approach the limits allowed for your ship's position and camera angle, the resolution of your view diminishes. Distance calculations and other information may be less reliable at these limits.

4) False planets and points can accumulate on the screen if you stay in one position for an extended period, or if the orbits of two planets plot too closely. To clean them away, press any key.

5) Distance readings occasionally include a planet that is not one of the three nearest to the ship. These fluctuations are obvious and should be ignored. For consistently accurate readings on distances to the planets, position your ship so you have a view which maintains a clear visual separation between the orbits. Camera angle does not affect distance readings. For example, X=020 BLUE, Y=050, Z=080, CA=030 gives good readings.

6) If your ship ever gets stuck, press H, move the ship once, and press H again. Occasionally the ship will move in two directions (ex. X and Z) at the same time. Just correct your position if you want to.

7) If a planet moves off screen on the left or right, its last position will

remain on the screen until it comes around in its orbit to re-enter the screen on the other side.

8) The maximum distance in the X and Y directions for your ship position is 127. If you exceed 127, the ship will jump to the other side of the VISIBLE SOLAR SYSTEM. Z can be from 11 to 255.

9) The field of vision of the ship's camera is 30 degrees in the Y direction (top to bottom of view screen) and 60 degrees in the X direction (left to right of view screen).

COMPUTER SCREEN

1) Data for Astrocalc is not included for the outer 3 planets—Uranus, Neptune and Pluto—because some of the resulting numbers do not fit the display format used. You can compare data on any two planets by switching from one screen to another and noting the numbers you are interested in.

2) If you see -*-.0, either one of the numbers in the comparison was a 0, or it was too large for astrocalcs math routines. Look up the data you wish as mentioned above in case 1. There are 2 other isolated comparisons where "unusual" answers show up. In both cases, the correct answers are approximately 10.

3) Astrocalc's display is cut off at 1 decimal point, but not rounded. For example, a .0 can be anything between 0 and .099.

PLANET SCREEN

1) The close up views of the planets are descriptive as opposed to photographic. They show the general appearance of the planets and demonstrate both rotation of the planets and the motion of up to four moons.

APPENDIX B

STARSHIP CONTROL KEYS

X	-ship left	(or cursor control key)
shift X	-ship right	(or cursor control key)
Y	-ship backward	(or cursor control key)
shift Y	-ship forward	(or cursor control key)
Z	-ship up	
shift Z	-ship down	
<	-camera forward	
>	-camera backward	
H	-switch ship's movement back and forth from hyperdrive (10 units or 50 million miles) to planetary drive (1 unit or 5 million miles)	

The H key can also be used to clean up false images from the view screen and to free your ship if it ever gets stuck. (See Appendix A)

TIME SCALE

The orbits screen is updated every 12 days. This means that each time you move your ship or see a new distance reading for a planet, about 12 Earth days have passed. You can see this for yourself by positioning your ship over the Earth and counting the number of 'distance to planet' updates it takes for the Earth to complete one revolution = 1 year = 365 days.

Now we can calculate how fast our ship travels. If we are moving 1 unit at a time = 5,000,000 miles then

$$\frac{\text{5,000,000 miles}}{\text{24 hours x 12 days}} = \text{17,000 miles per hour}$$

Hyperdrive of 10 units per motion is 170,000 miles per hour.

APPENDIX C – FOOTNOTES

*Fluctuations in the DISTANCE readings to the planets on the screen at this time are due to approximations used in the calculations. The fluctuations, though small, are very noticeable now because your ship is directly above the Sun; therefore, the distances from the ship to the planets is not changing. Occasionally Mars and Jupiter are shown even though they are not closer to the ship than Mercury, Venus or Earth. When you move your ship away from its central position over the Sun, this fluctuation will occur infrequently. In order to achieve the high computing speed needed in this program, the data used in calculation is often approximated to a tolerance of several percent.

**The calculations done by Astrocalc are cut off at the first decimal digit of the result. Therefore, a .1 can be anything from .1 to .199. To get more accurate comparisons when there is only a decimal digit shown, do the comparison in the reverse direction. For example, if you compare the radius of Mercury to Earth, you will get .3, but if you compare Earth to Mercury, you will get 2.7. The 2.7 is the more correct relationship.

COMMAND CHART

WHEN AT:	PRESS:	TO (GO TO):
Opening mode	F1	Orbits Screen
Orbits Screen	C	Planetary Computer
	P	Planet Representations
	X, cursor	Move the ship left
	Shift X, or Shift cursor	Move the ship right
	Y, cursor	Move the ship down screen
	Shift Y, or Shift cursor	Move the ship up the screen
	Z	Move the ship up (above the Solar Plane)
	Shift Z	Move the ship down (below the Solar Plane)
	<	Swing camera forward
	>	Swing camera backward
	H	Switch ship's movement back and forth from hyperdrive
Planetary Computer	P	Planet Data Charts (and Astrocalc)
	Y	Your weight and age
	E	Exit (to Orbits Screen)
Planet Data Charts	A	Astrocalc Function
	E	Exit (to Planetary Computer)
Planet Representations	C	Planetary Computer
	P	Other Planet Representations
	O	Orbits Screen

INFORMATION ABOUT THE PLANETS

	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto	Sun	Moon
Atmosphere	None	CO_2	N_2, 0_2	CO_2	H_2, He	H_2, He ~~CO_4~~ CH_4	H_2, He CH_4	H_2, He CH_4	Frozen CH_4 on surface	—	None
Temperature											
Fahrenheit	-275,+620	900	72	- 9	-240	-300	-340	-370	-380	9900	-270
Centigrade	-170,+330	480	22	-23	-150	-180	-210	-220	-230	5770	-170
Volume (Earth = 1)	0.05	0.88	1.00	0.49	1,316	755	52	44	0.01	1.3 million	0.02
Albedo	0.06	0.72	0.39	0.16	0.70	0.75	0.90	0.82	0.14	—	0.07
Mean Apparent Diameter of Sun (as seen from planet)	1°22'38"	44'15"	31'59"	21'00"	6'09"	3'22"	1'40"	1'04"	49"	—	31'59"
Brightest Apparent Magnitude	-1.9	-4.4	—	-2.8	-2.6	-0.4	+5.5	+7.6	+13.7	-26.8	-12.7
Known Satellites	0	0	—	2	14?	12?	5	2	1	—	—
SYMBOL	☿	♀	⊕	♂	♃	♄	♅	♆	♇	☉	☾

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	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Mean Distance From Sun									
Million Miles	36.0	67.2	92.9	141.7	483.7	886.9	1783.4	2794.6	3667
M Million Kilometers	57.9	108.2	149.6	227.9	778.3	1427.0	2869.6	4496.6	5900
Astronomical Units	0.387	0.723	1.000	1.524	5.203	9.539	19.18	30.06	39.44
Least Distance From Sun									
Million Miles	28.6	66.8	91.4	128.4	460.3	837.5	1699	2771	2750
Million Kilometers	46.0	107.5	147.1	206.7	740.6	1346	2734	4458	4425
Greatest Distance From Sun									
Million Miles	43.4	67.7	94.5	154.7	507.2	936.2	1868	2819	4584
Million Kilometers	69.8	108.9	152.1	249.2	816.0	1506.4	3005	4535	7375
Period of Revolution	88 d.	224.7 d.	365.26 d.	687.0 d.	11.86 y.	29.46 y.	84.01 y.	164.8 y.	247.7
Orbital Velocity									
Miles per Second	29.7	21.8	18.5	15.0	8.1	6.0	4.2	3.4	2.9
Kilometers per Second	47.9	35.0	29.8	24.1	13.1	9.6	6.8	5.4	4.7
Inclination of Axis	28°	177°	23°27'	23°59'	3°05'	26°44'	97°55'	28°48'	?
Inclination of Orbit	7.0°	3.4°	0.0°	1.8°	1.3°	2.5°	0.8°	1.8°	17.2
Eccentricity of Orbit	0.206	0.007	0.017	0.093	0.048	0.056	0.047	0.009	0.25

	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto	Sun	Moon
Rotation Period	58d 15H 30m	243d* 2h 24m	23H 56m 04s	24H 37m 23s	9h 55m 29s	10h 14m	10h 49m*	15h 48m	6d 9h	25-35d	27d 07h 43m
Equatorial Diam.											
Miles	3,014	7,545	7,927	4,220	88,630	74,700	30,000	30,500	1500	865,000	2,160
Kilometers	4,850	12,140	12,756	6,790	142,600	120,200	49,000	49,000	2400	1,392,000	3,480
Oblateness	0	0	0.003	0.009	0.06	0.1	0.06	0.02	?	0	
Mass (Earth = 1)	0.055	0.815	1.000	0.108	317.8	95.1	14.5	17.2	0.002	333,434	0.0123
Masses Contained in Sun	6,000,000	408,400	333,434	3,098,500	1,047	3,498	22,900	19,300	200,000,000	1	26,700,000
Density (Water = 1)	5.4	5.2	5.52	3.95	1.34	0.70	1.6	2.3	1?	1.41	3.34
Surface Gravity (Earth = 1)	0.37	0.88	1.00	0.38	2.61	1.15	1.06	1.43	0.05	27.9	0.16
Escape Velocity											
Miles per Second	2.6	6.4	7.0	3.1	37.9	23.0	13.7	15.5	0.7	383.9	1.5
Kilometers per Second	4.2	10.3	11.2	5.0	61.0	37.0	22.0	25.0	1.1	617.7	2.38

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***Retrograde: Rotates from East to West; opposite from other planets**